PHYSICS 222, Fall 1995
Final Exam, Monday, December 11, 1995, 7:00 – 9:00 pm
VERSION A

Instructions:

1. Check that your multiple choice answer sheet ("bubble sheet") is marked "A" on the upper right hand corner of the front side. If it is not so marked, call one of the instructors. Also, the version should be marked in question 101 on the back of the answer sheet. Also check the version on pages 5 and 8.

2. The first ten questions of this exam (numbered from 36 to 45) are about the laboratory part of the course. Each correct answer is **worth 2 points**. All students need to answer these questions, including students with a lab waiver (as explained in the syllabus).

3. The next eleven questions (numbered from 46 to 56) are about material covered in earlier exams. The last eleven questions (57 to 67) are about recent material (thermodynamics). Correct answers to these questions are **worth 4 points each**.

4. Please note that questions 56 and 67 are bonus questions. You can get a total of 108 points if all questions are answered correctly, but 100 points is considered a full score.

5. This exam has 13 pages numbered at the bottom from 1 to 13. All pages are printed on front and back except for the last page.

6. In marking the multiple choice answer sheet use a number 2 pencil. Do NOT use ink. If you did not bring a pencil, ask for one. Fill in the appropriate circles completely. If you need to change an entry, you must first completely erase your previous entry. We suggest that you also circle the correct answer on the exam sheet.

7. Make sure that your name, student identification number, and section number are filled in at the appropriate places on the computer answer sheet.

8. When you are done with the exam at the end of the period, put everything (computer answer sheet, formula sheet, scratch paper, and everything else) back into the folder. Give the folder to the TA for your section. You will not receive credit for any material that may be missing from your folder when your TA opens it for sorting after the exam.

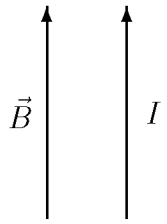
9. You will need a calculator for some of the questions. If you did not bring a calculator, or if your calculator stops working during the exam, call one of the instructors. We have a limited number of calculators available.

10. Ask one of the instructors for assistance, if you have additional questions.

11. Good luck and have a good winter break !!!

Stefan Zollner and Joseph Shinar, December 12, 1995.

46. A current carrying wire is parallel to a magnetic field $\vec{B}$ that starts at the bottom of the page in a direction parallel to the side of the page. What is the direction of the magnetic force on the wire?



(A) Into the page.
(B) Out of the page.
(C) Toward the right edge of the page.
(D) Toward the left edge of the page.
(E) **None of the above.**

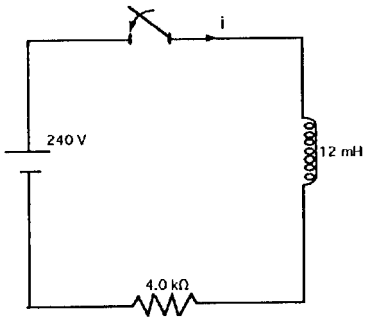
47. A very long thin wire carries a current and produces a magnetic field. Under what condition will the magnetic field at a certain distance increase by a factor of four?

(A) By doubling the current and doubling the distance from the wire.
(B) **By doubling the current and cutting the distance from the wire in half.**
(C) By doubling the distance from the wire.
(D) By doubling the current.
(E) By cutting the distance from the wire in half.

48. The magnetic flux trough a coil changes from 0.0273 Tm^2 to zero in 0.824 s. If there are 100 turns in the coil, what is the induced *emf*?

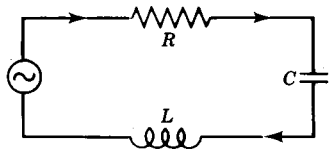
(A) 1.23 V.
(B) 4.14 V.
(C) **3.31 V.**
(D) 33.1 mV.
(E) 41.4 mV.

49. The switch is closed at t=0, when the current I is zero. When I=15 mA, what is the potential difference in V across the inductor. Hints: The battery voltage is 240 V, the inductance is 12 mH, and the resistance is 4.0 kΩ.



(A) 240 V.
(B) 0 V.
(C) 60 V.
(D) **180 V**
(E) None of the above.

50. For an RLC circuit, R=20 Ω, C=1 μF, L=2.0 mH, and the amplitude of the emf of the AC generator is 160 V. If the frequency of the AC generator could be varied (but all else is fixed at the values given above), what would be the largest possible amplitude of the current in the circuit?



(A) 2.71 A.
(B) 4.72 A.
(C) 5.00 A.
(D) **8.00 A.**
(E) 10.0 A.

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51. The Doppler effect causes the sound from a source moving toward an observer to apear to have a

(A) greater amplitude.
(B) smaller amplitude.
(C) greater speed.
(D) lower frequency.
(E) **higher frequency.**

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52. Write the equation of a wave, traveling along the + x axis with an amplitude of 0.02 m, a frequency of 440 Hz, and a speed of 330 m/s.

(A) $y(x,t) = 0.02 \text{ m } \sin[880\pi \ (x/330 - t)]$.
(B) $y(x,t) = 0.02 \text{ m } \cos[880\pi \ (x/330 - 440t)]$.
(C) $y(x,t) = 0.02 \text{ m } \sin[880\pi \ (x/330 + t)]$
(D) $y(x,t) = 0.02 \text{ m } \sin[2\pi \ (x/330 + 440t)]$
(E) $y(x,t) = 0.02 \text{ m } \cos[2\pi \ (x/330 - 440t)]$

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53. According to Einstein's theory, the energy of a photon is

(A) proportional to its wavelength.
(B) **proportional to its frequency.**
(C) constant, since the speed of light is a constant.
(D) quantized, since it always appears in bundles of size 1.6×10^{-19} C.
(E) proportional to the square of the wavenumber.

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54. For an **open** pipe of length L (open at both ends), the wavelength of the **second** harmonic is

(A) L/4
(B) L/3
(C) L/2
(D) **L**
(E) 2L

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55. The half-life of ^{131}I (iodine) is 8.04 days. Three days after it was prepared, its activity was 0.5 μCi. How many μCi were intially prepared?

(A) 0.60 μCi.
(B) 0.70 μCi.
(C) **0.65 μCi.**
(D) 0.55 μCi.
(E) 0.39 μCi.

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56. Stars (like our sun) produce energy by "burning" hydrogen. In a complicated cycle, four hydrogen atoms are fused into one helium atom. The mass of a hydrogen atom is 1.007825 u and that of a helium atom is 4.002603 u, where 1 u=1.66×10^{-27} kg. How much energy is produced **for each hydrogen atom "burnt"**?

(A) **1.07×10^{-12} J.**
(B) 2.07×10^{-12} J.
(C) 4.28×10^{-12} J.
(D) 2.68×10^{-13} J.
(E) 3.28×10^{-12} J.

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57. A car engine delivers about 100 kW of mechanical power. If the efficiency of the engine is 25%, how much energy is released into the atmosphere (cold reservoir) every second?

(A) 100 kJ.
(B) 400 kJ.
(C) 500 kJ.
(D) 200 kJ.
(E) **300 kJ.**

For the next three questions, you need to know some thermal properties of iron and water:

	iron	water
coefficient of volume expansion	33×10^{-6} K^{-1}	210×10^{-6} K^{-1}
specific heat	448 J/kg·K	4186 J/kg·K
boiling point		100°C
heat of vaporization		2.26 MJ/kg
density	7.86×10^{3} kg/m^3	1.00×10^{3} kg/m^3

58. A red-hot iron horseshoe (initially at 650°C with a mass of 1.5 kg) is dropped into a bucket containing 10 kg of water at 15°C. What is the final temperature of the horseshoe? (Neglect the heat capacity of the container.)

(A) 20°C.
(B) **25°C.**
(C) 10°C.
(D) 30°C.
(E) 80°C.

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59. Now imagine that the horseshoe is dropped into a lake (with a temperature of 0°C). Since the lake is very large, the temperature of the lake does not change. What is the **work done** by the horseshoe in this thermodynamical process? Hint: The air pressure is 1.013×10^{5} Pa.

(A) **−0.415 J.**
(B) +0.415 J.
(C) −0.805 J.
(D) +0.805 J.
(E) +8.97 kJ.

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60. The horseshoe is dropped into a lake (with a temperature of 0°C). Since the lake is very large, the temperature of the lake does not change. How does the entropy of the horseshoe change in this process?

(A) The entropy of the horseshoe does not change, since the process is reversible.
(B) **The entropy of the horseshoe decreases by 819 J/K.**
(C) The entropy of the horseshoe increases by 819 J/K.
(D) The entropy of the horseshoe increases by 4093 J/K.
(E) The entropy of the horseshoe decreases by 4093 J/K.

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61. A freezer is designed to hold frozen food at a temperature of $-30°$C. Assume that the freezer uses an (ideal) Carnot cycle. Which of these statments is **correct?**

(A) **In order to minimize your electric utility bills, you should keep the freezer in the basement, where the temperature is 15°C.**

(B) In order to minimize your electric utility bills, you should keep the freezer in the kitchen, where the temperature is 25°C.

(C) It does not matter where you keep the freezer, because the coefficient of performance only depends on the temperature of the freezer section, not on the temperature outside.

(D) If you leave the door of the freezer open on a hot day, you can use the freezer as an air conditioner. (Your food will spoil, of course.)

(E) The first law of thermodynamics states that the entropy of the universe decreases when you turn on the freezer.

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62. The concrete sections of a highway are designed to be 30 m long at 10°C. Expansion slots have to be cut between the sections to prevent buckling in the summer when the temperature of the roadway could rise to 60°C. What is the minimum slot width that has to be cut if the coefficient of linear expansion of concrete is 1.2×10^{-5} K^{-1}.

(A) 9.0 cm.

(B) 2.2 cm.

(C) **1.8 cm.**

(D) 0.91 cm.

(E) 0.46 cm.

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63. A lump of dry ice (solid CO_2, carbon dioxide) with a mass of 50 g is sealed in an evacuated container with a volume of 5.0 L. The solid CO_2 is warmed to 300 K, causing it to evaporate. What is the pressure inside the container due to the CO_2 gas, if the molecular mass of CO_2 is 44 g/mol. (1 atm=1.013×10^5 Pa, 1 L=10^{-3} m^3).

(A) 3.8 atm.

(B) 4.2 atm.

(C) **5.6 atm.**

(D) 5.8 atm.

(E) 6.2 atm.

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64. One hydrogen molecule (H_2) has a mass of 2 u (1 u=1.66×10^{-27} kg). One water molecule (H_2O) has a mass of 18 u. If the average (rms) speed of molecules in a hydrogen gas at 20°C and 1 atm is 1902 m/s, what is the average (rms) speed of molecules in a wator vapor at 20°C and 0.1 atm?

(A) 1902 m/s.
(B) **634 m/s.**
(C) 5379 m/s.
(D) 190.2 m/s.
(E) 601 m/s.

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65. The internal energy of an isolated system

(A) depends on the volume.
(B) depends on the presure.
(C) depends on volume and pressure.
(D) depends on volume and temperature.
(E) **depends on the temperature.**

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66. Five moles of an ideal gas expand isothermally at 100°C to five times its initial volume. Which of the following statements is **correct?**

(A) No heat flows into the system, since the process is isothermal.
(B) **Heat in the amount of 2.5×10^4 J flows into the system.**
(C) Heat in the amount of 2.5×10^4 J is released by the system.
(D) Heat in the amount of of 7.8×10^4 J flows into the system.
(E) Heat in the amount of 7.8×10^4 J is released by the system.

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67. Which of the following statements is **NOT** equivalent the **second** law of thermodynamics:

(A) Heat likes to flow from a hot body to a cold body. Heat will not flow spontaneously from a cold object to a hot object.
(B) It is impossible to construct a heat engine which converts all heat input into work and releases no heat to the environment.
(C) **The heat absorbed by a heat engine equals the work done plus the heat released to the environment.**
(D) All heat engines have an efficiency of less than 100%.
(E) The entropy of the universe increases in all natural processes.
